

International Joint Usage/Research Promotion Workshop

IOES(Institute of Ocean Energy, Saga University, Japan) accepts applications for joint research using research equipment related to ocean energy at Saga University. For each joint research application submitted, after review, IOES provides support for research expenses and travel expenses to Japan. In this WORKSHOP, we would like to hold an open WORKSHOP on how to use the equipment, the application form, and your requests. We look forward to your participation

Date : 09th March 2025 [JST] (10:00~12:00)

Form : Online (zoom) Free event!

PROGRAM

- Opening Remarks
10:00~10:10 Yasuyuki Ikegami, Director
- Introduction of the Institute of Ocean Energy
10:10~10:30 Yasuyuki Ikegami, Professor
- Research on Wave Power Generation in IOES
10:30~10:45 Yasutaka Imai, Associate Professor
- Research on Tidal Current Power Generation in IOES
10:45~11:00 Wakana Tsuru, Associate Professor
- Research on Offshore Wind Power in IOES
11:00~11:15 Shigeo Yoshida, Professor
- Research on Ocean Thermal Energy Conversion in IOES
11:15~11:30 Yasuyuki Ikegami, Professor
- Free Discussion
11:30~11:55 All participants
- Closing Remarks
11:55~12:00

Join Zoom Meeting

<https://zoom.us/j/97663451867?pwd=hFEP9y2TwN3E6z9v47ZcMc4z14UhKa.1>

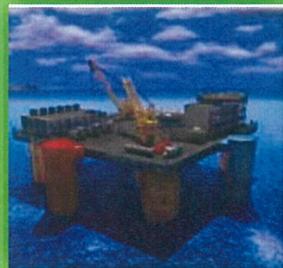
Meeting ID: 976 6345 1867

Passcode: 728261

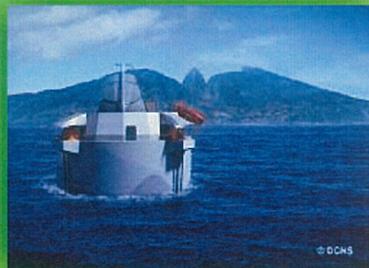
ZOOM

Ocean Thermal Energy Department

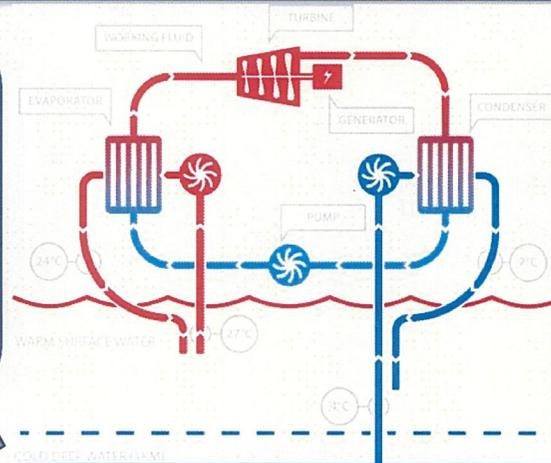
Concept diagrams



USA 10MW project



France 10MW project

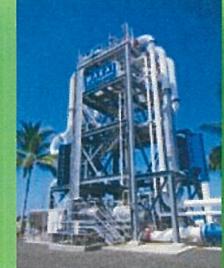


Working principle of OTEC

Demonstration plants



Kumejima 100kW OTEC



Hawaii 105kW OTEC

Research on heat exchangers

Research on system integration

Plate heat exchanger



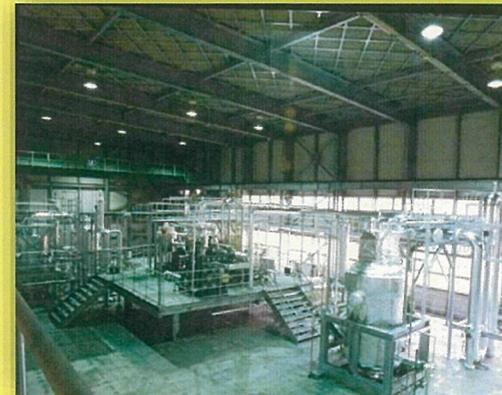
Deep ocean water plate heat exchanger experiment (Kumejima 2015~)

Boiling phenomena

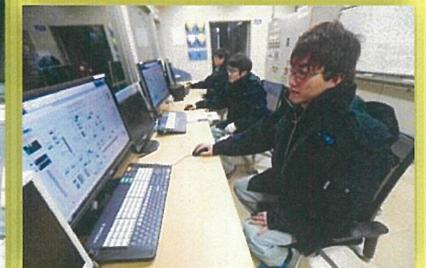


Boiling visualization experiment (Imari)

- Forced convection boiling heat transfer in heat exchangers using ammonia as a working fluid
- Research on heat transfer surface materials for plate heat exchangers



30kW OTEC equipment (Imari)



Operation in the OTEC monitoring room

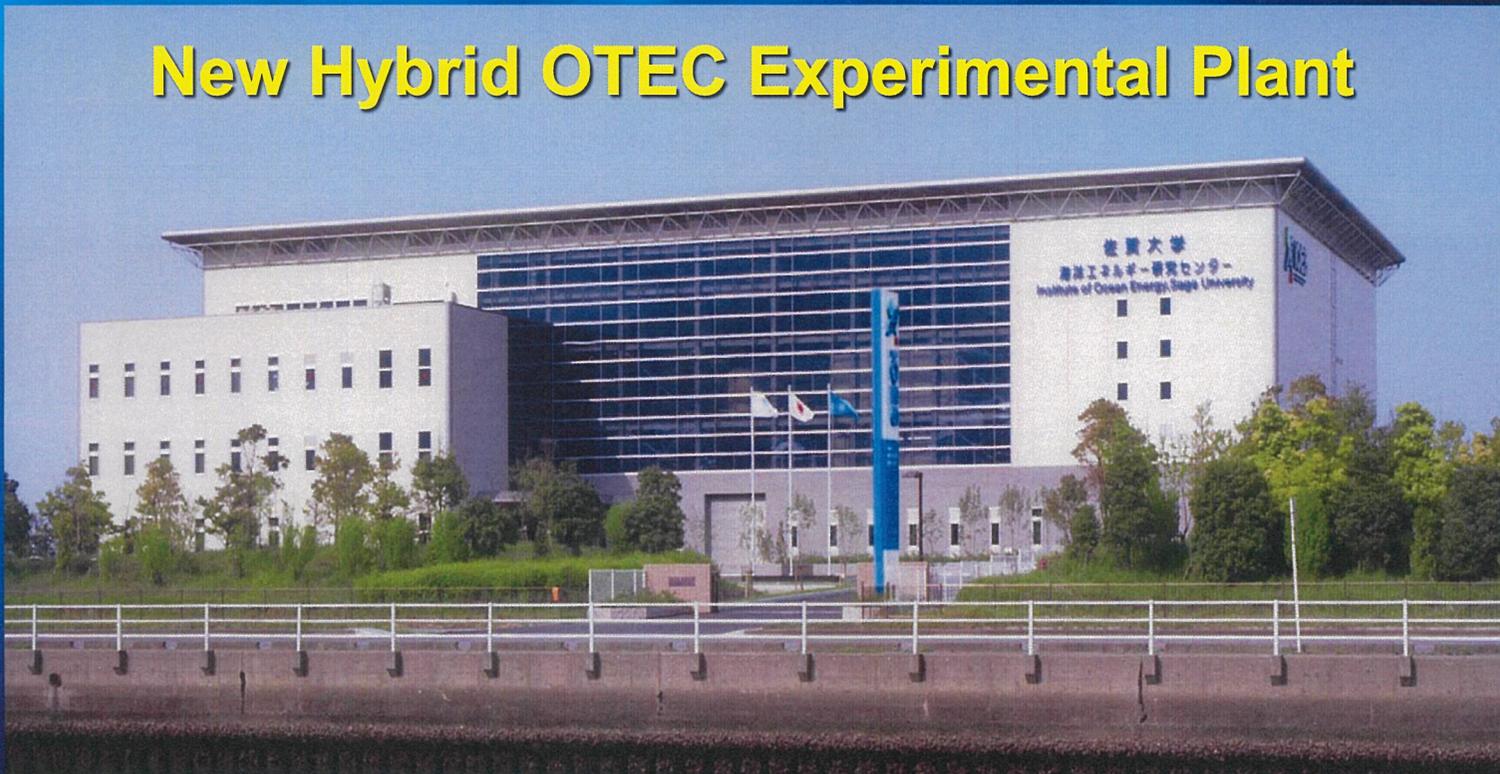
- Research on a novel high performance ocean thermal energy conversion system
- Research on seawater desalination using flash evaporation
- Development of a plate heat exchanger using a 3D printer

Research on OTEC

1. OTEC System
2. Heat Exchanger
3. Anti-Bio Fouling
4. Condensation/Evaporation
5. Multi-use deep sea water application

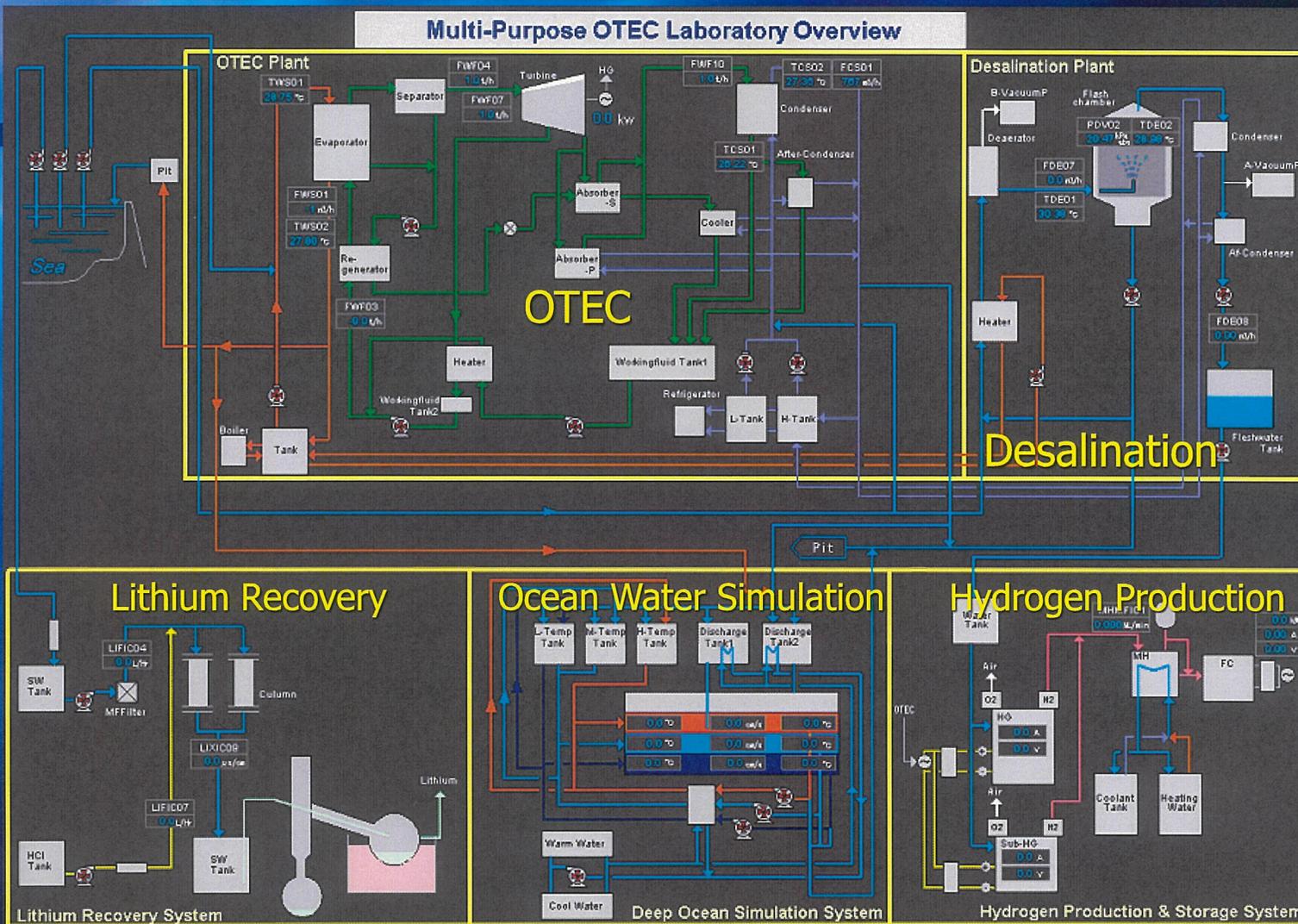
Institute of Ocean Energy, Saga University (IOES)

New Hybrid OTEC Experimental Plant



Completion in 2003

Multi-Purpose OTEC Laboratory Overview



OTEC Plant

Desalination Plant

OTEC

Desalination

Lithium Recovery

Ocean Water Simulation

Hydrogen Production

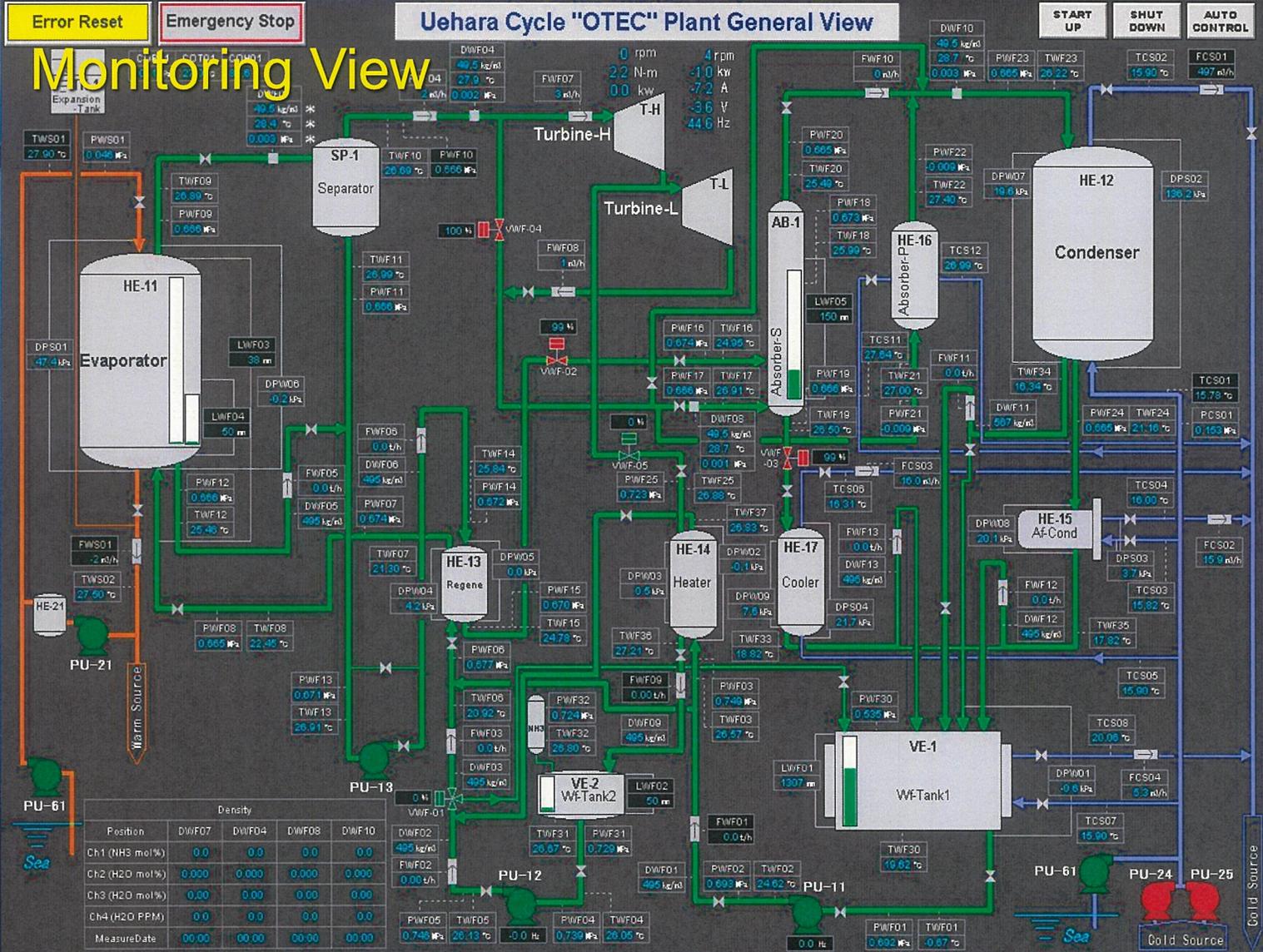
Lithium Recovery System

Deep Ocean Simulation System

Hydrogen Production & Storage System

Turbine for OTEC using Ammonia/Water Mixtures as Working Fluid(30kW)





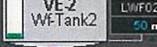
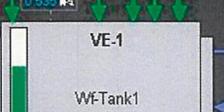
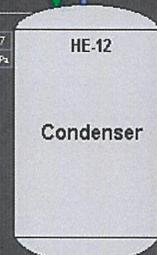
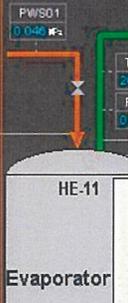
Error Reset

Emergency Stop

Uehara Cycle "OTEC" Plant General View

START UP SHUT DOWN AUTO CONTROL

Monitoring View



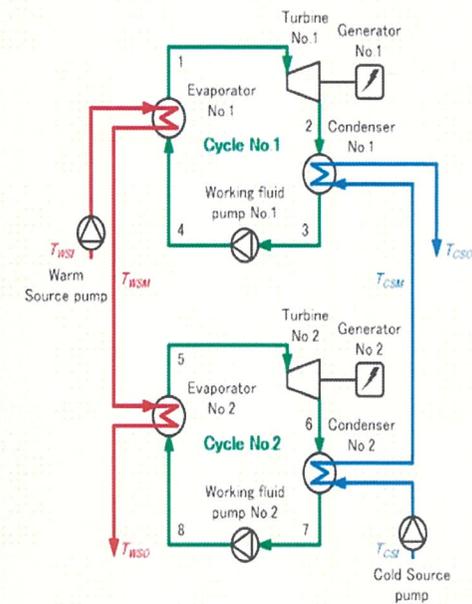
Position	Density			
	DWFO7	DWFO4	DWFO8	DWFO10
Ch1 (NH3 mol%)	0.0	0.0	0.0	0.0
Ch2 (H2O mol%)	0.000	0.000	0.000	0.000
Ch3 (H2O mol%)	0.00	0.00	0.00	0.00
Ch4 (H2O PPM)	0.0	0.0	0.0	0.0
MeasuraDate	00:00	00:00	00:00	00:00

Position	Density	
	DWFO2	DWFO4
Ch1 (NH3 mol%)	0.0	0.0
Ch2 (H2O mol%)	0.000	0.000
Ch3 (H2O mol%)	0.00	0.00
Ch4 (H2O PPM)	0.0	0.0
MeasuraDate	00:00	00:00

Position	Density	
	DWFO1	DWFO2
Ch1 (NH3 mol%)	0.0	0.0
Ch2 (H2O mol%)	0.000	0.000
Ch3 (H2O mol%)	0.00	0.00
Ch4 (H2O PPM)	0.0	0.0
MeasuraDate	00:00	00:00

Position	Density	
	DWFO3	DWFO4
Ch1 (NH3 mol%)	0.0	0.0
Ch2 (H2O mol%)	0.000	0.000
Ch3 (H2O mol%)	0.00	0.00
Ch4 (H2O PPM)	0.0	0.0
MeasuraDate	00:00	00:00

NEW OTEC SYSTEM Multi-system (NEDO Project)



The Expecting 10~20% Increase of Power output

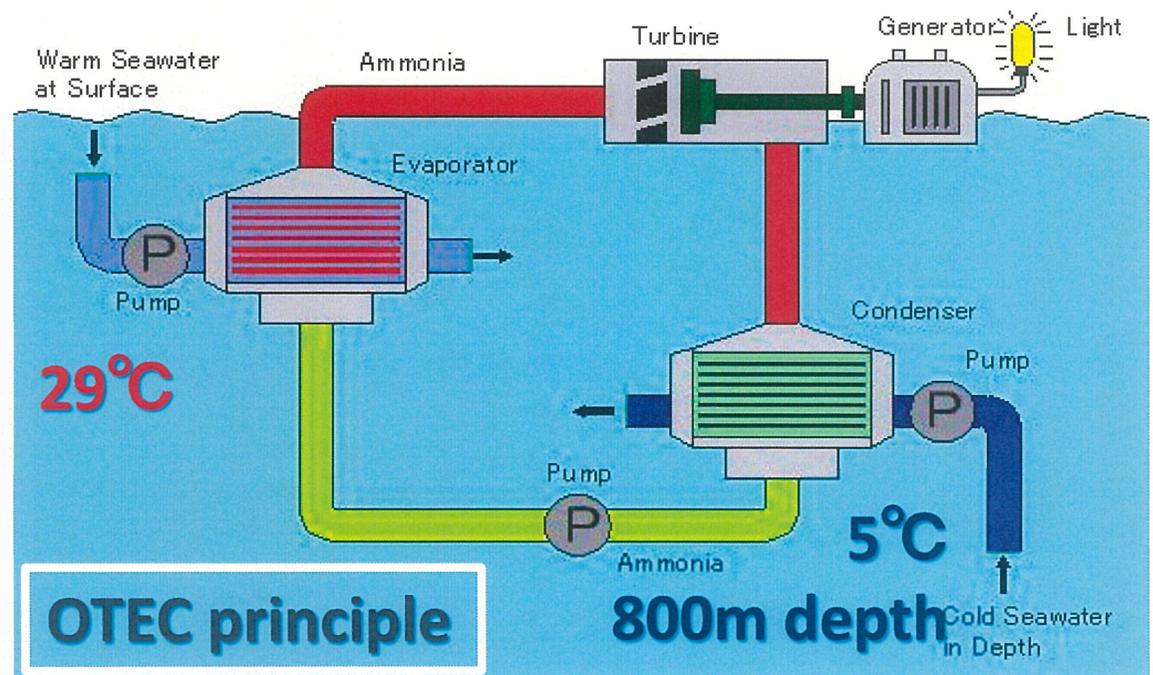
Development of Advanced Hybrid Ocean Thermal Energy Conversion (OTEC) Technology for Low Carbon Society and Sustainable Energy System: First Experimental Plant of Malaysia

<Project purpose>

Malaysia Model is established

<Project term>

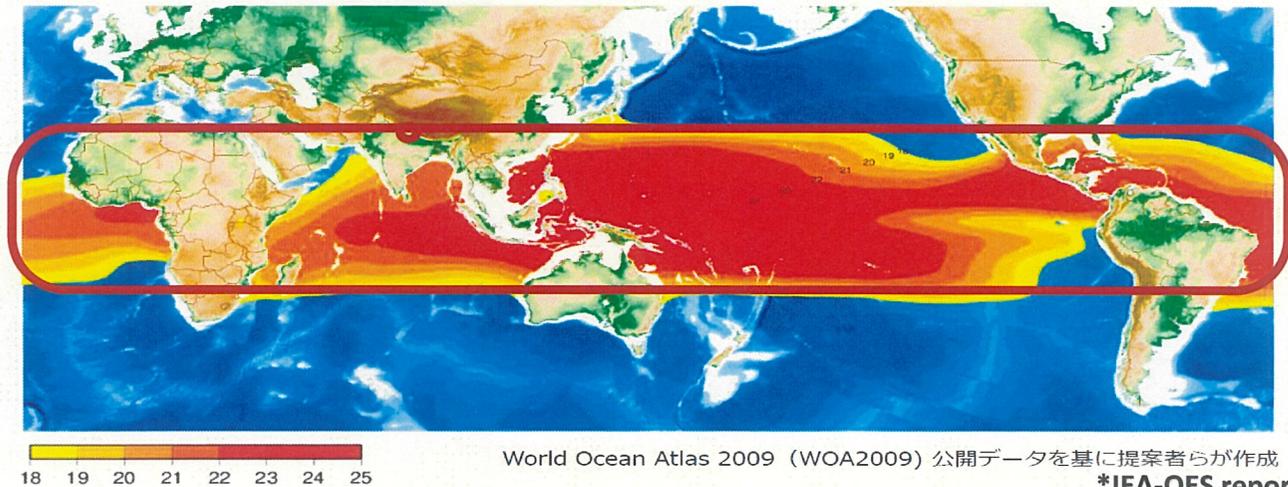
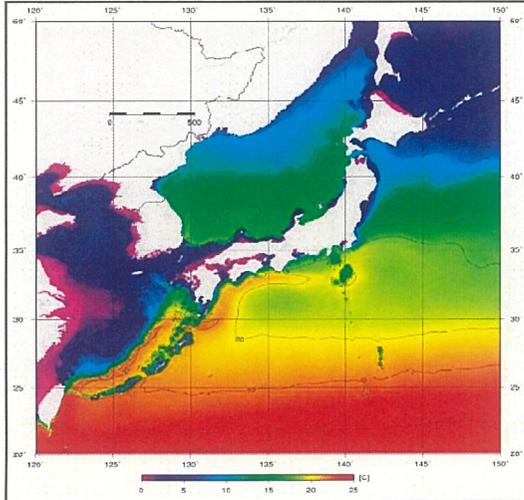
April 2019 – March 2025



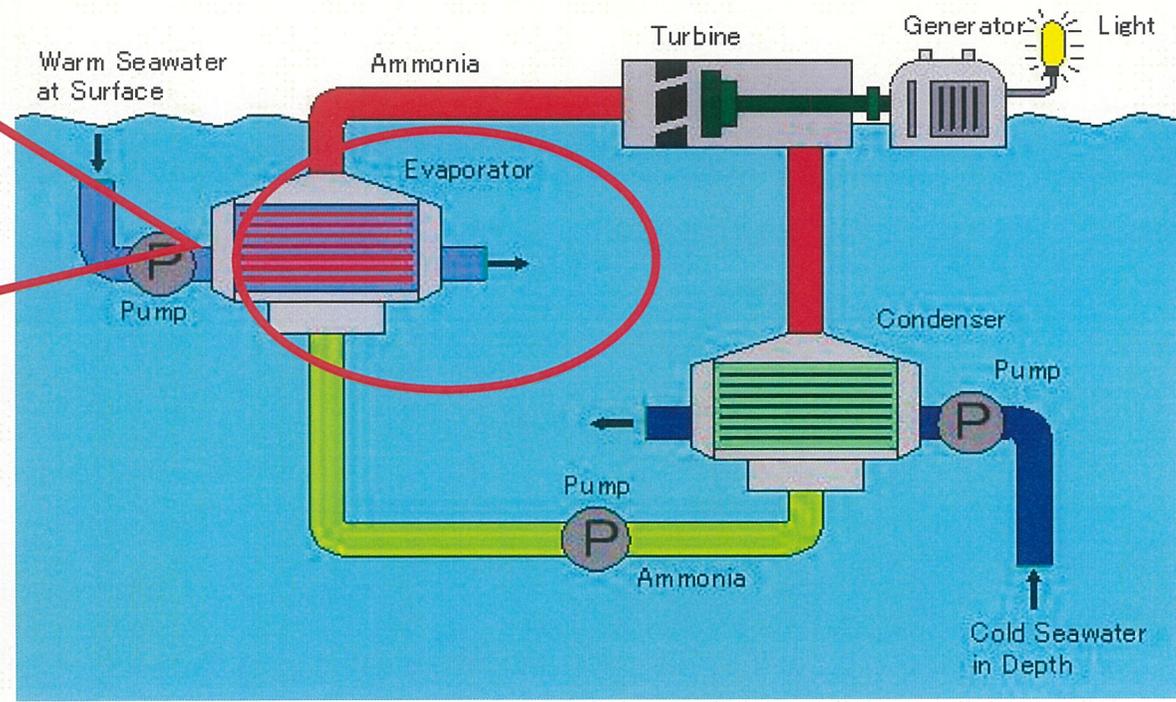
<Overall goal>

The implementation of combination of Hybrid OTEC (H-OTEC) and deep seawater application, so called "Malaysia Model", is commenced in Malaysia

Remaining technical issue to expand to Asian countries



World Ocean Atlas 2009 (WOA2009) 公開データを基に提案者らが作成
*IEA-OES report

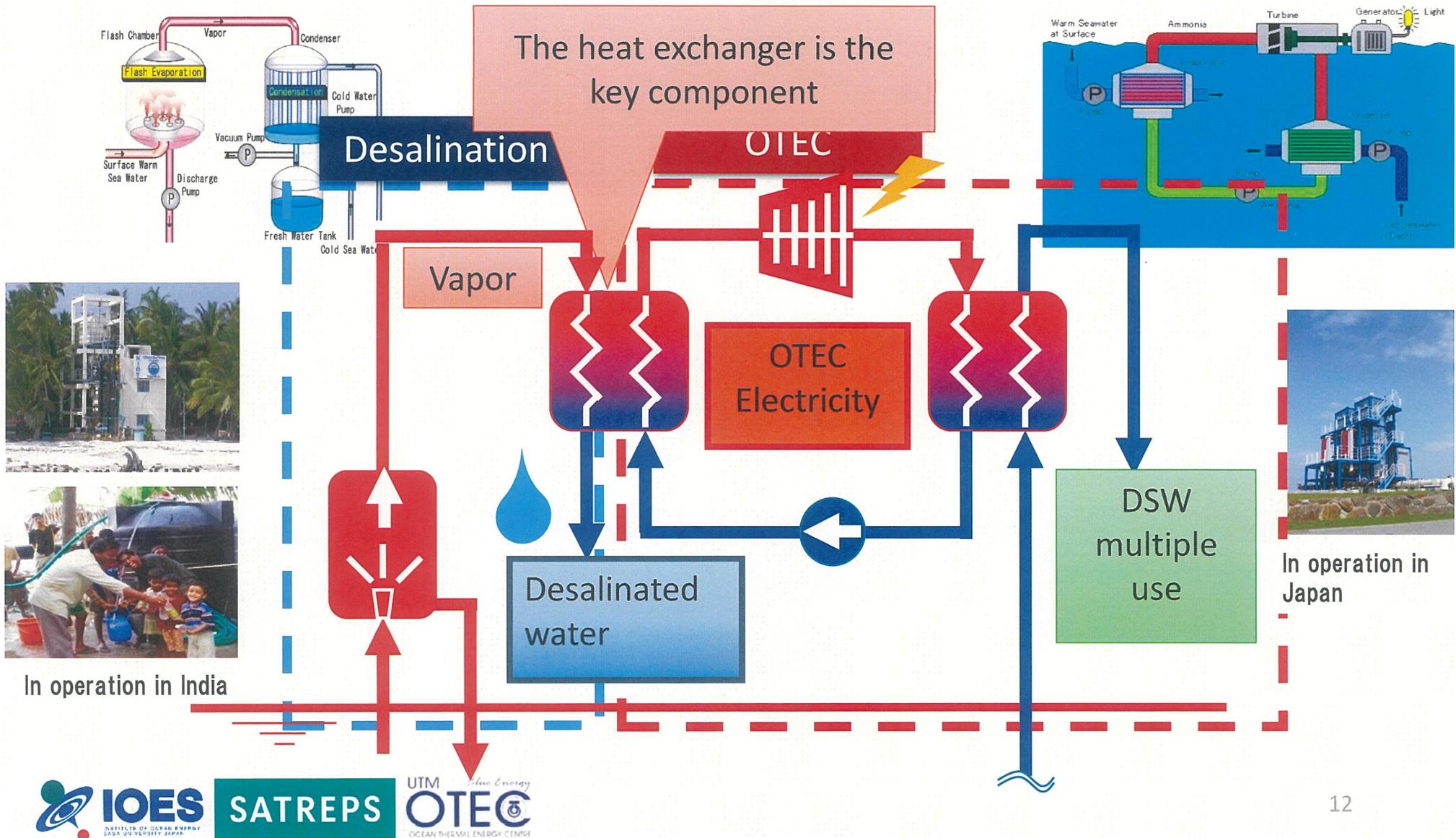


Not to use the surface seawater directly

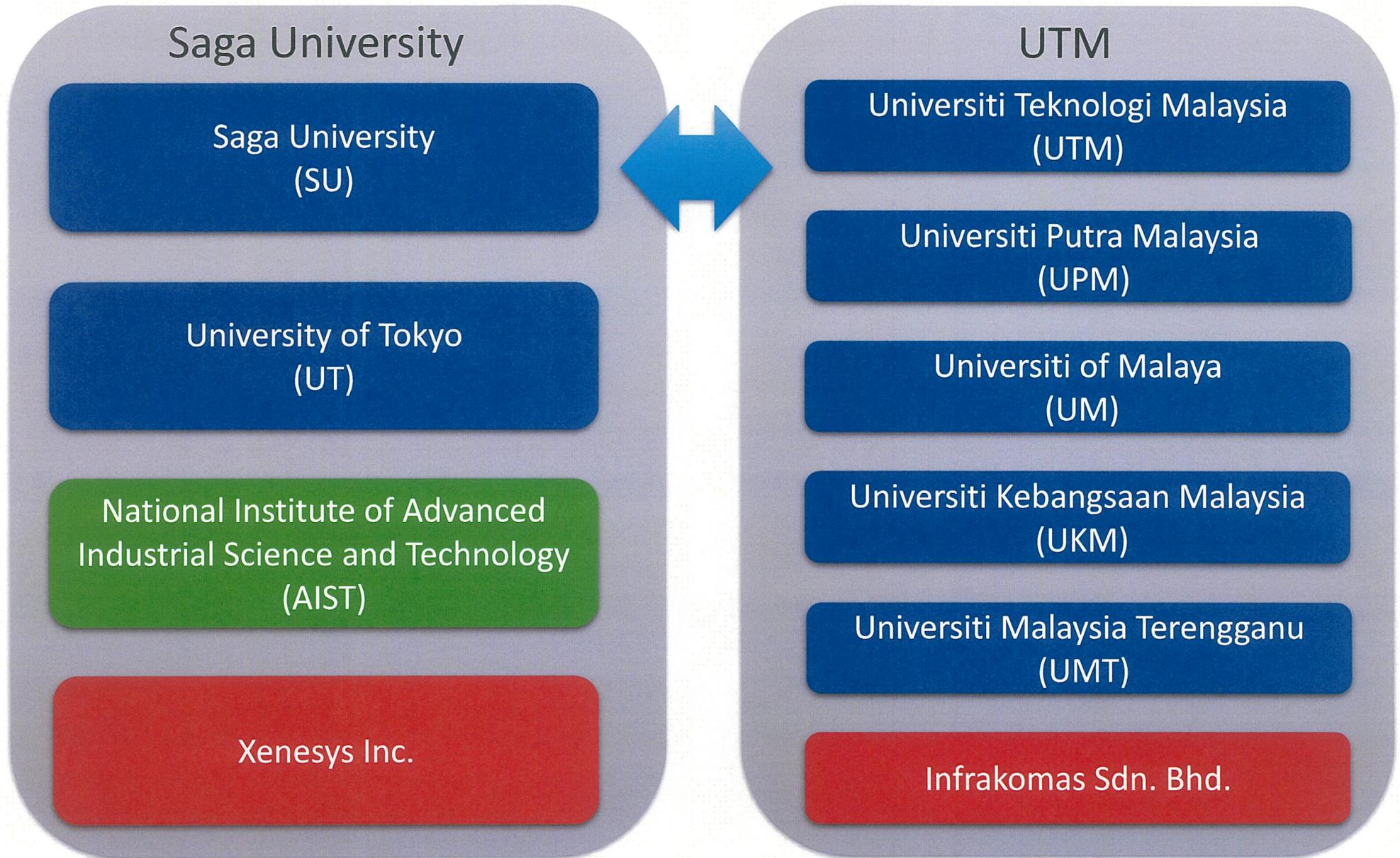
↓
Hybrid OTEC

What is hybrid OTEC (H-OTEC)

New system combined OTEC and desalination to promote the commercialization.
The facility will be the first operational plant in the world.



Structure chart





RESEACH MILESTONE

H-OTEC System Installation



UPM-UTM OTEC Centre Launches World's First Hybrid OTEC System

20 January 2025 | Port Dickson, Malaysia

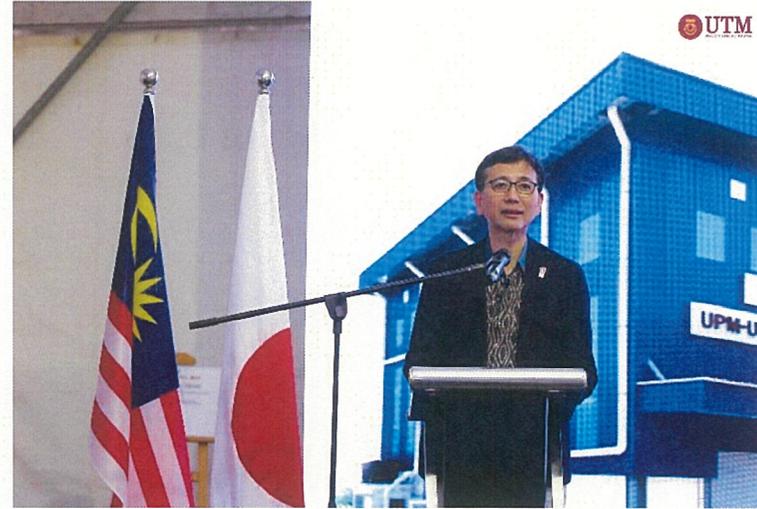


UPM-UTM OTEC Centre Launches World's First Hybrid OTEC System

20 January 2025 | Port Dickson, Malaysia



**HE HONOURABLE DATUK TS. MUSTAPHA SAKMUD,
DEPUTY MINISTER OF HIGHER EDUCATION.**



**His Excellency Noriyuki Shikata
Ambassador of Japan to Malaysia**



Prof. Dr. Ichihiko Toyoda, Vice-President at Saga University, Japan

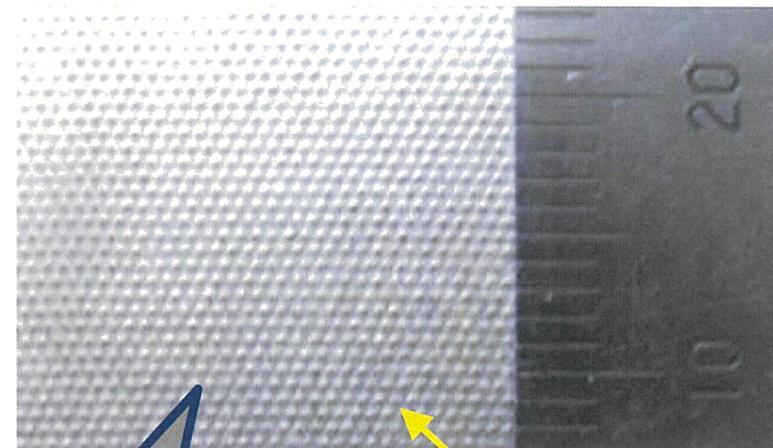


“mass-produced high heat transfer titanium sheet HEET™”

Normal surface
(back face)



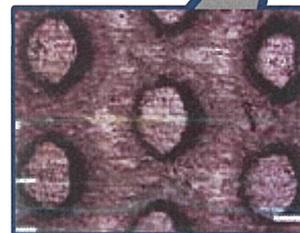
Special surface
(for evaporating heat transfer)



Special surface treated sheet

Grade : 1

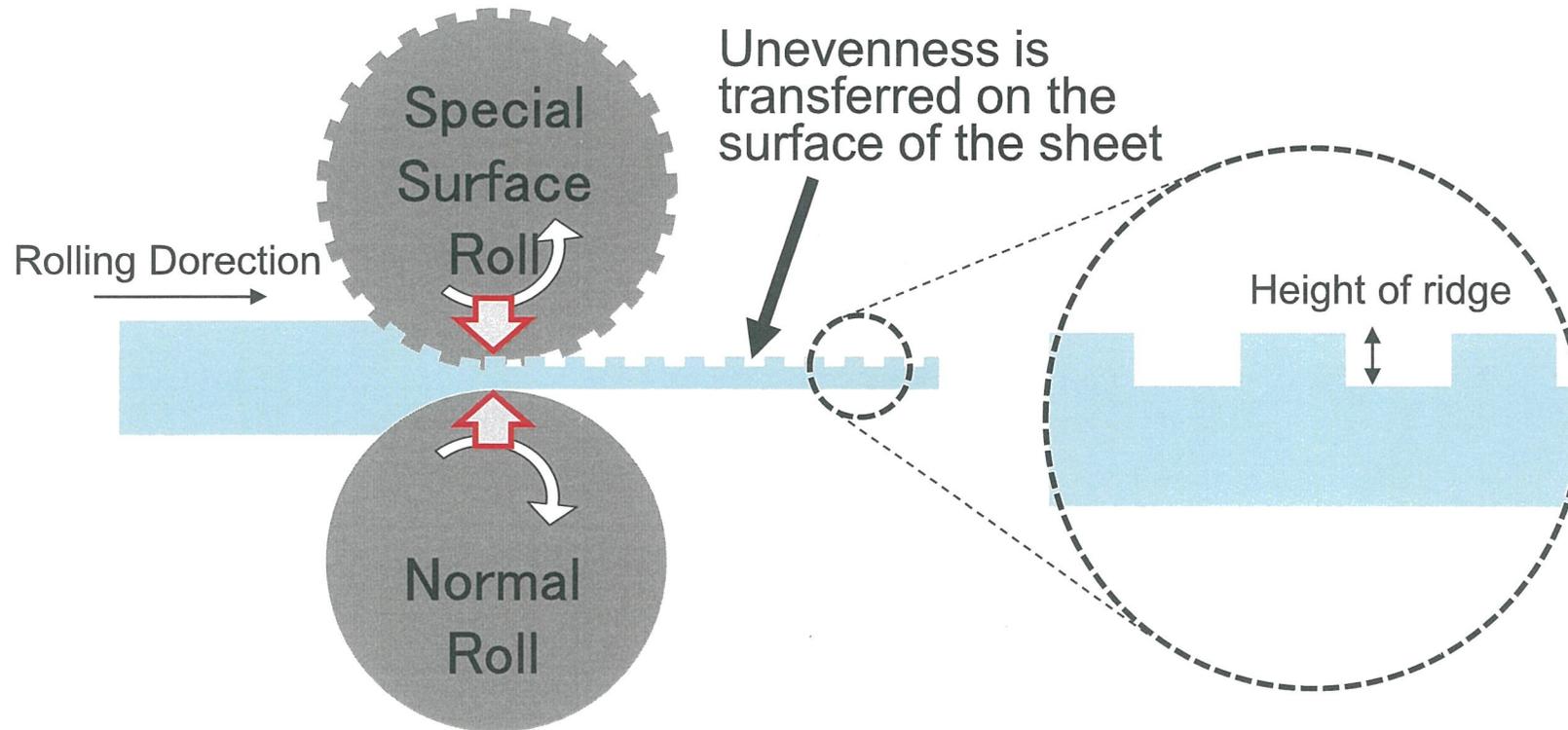
Thickness : 0.4~0.6mm



“Polka dots”



Transfer – printing technology in the rolling process

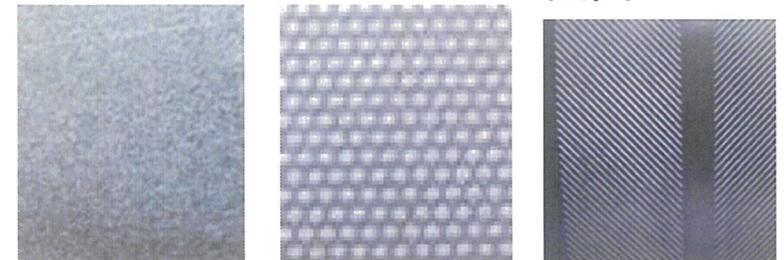
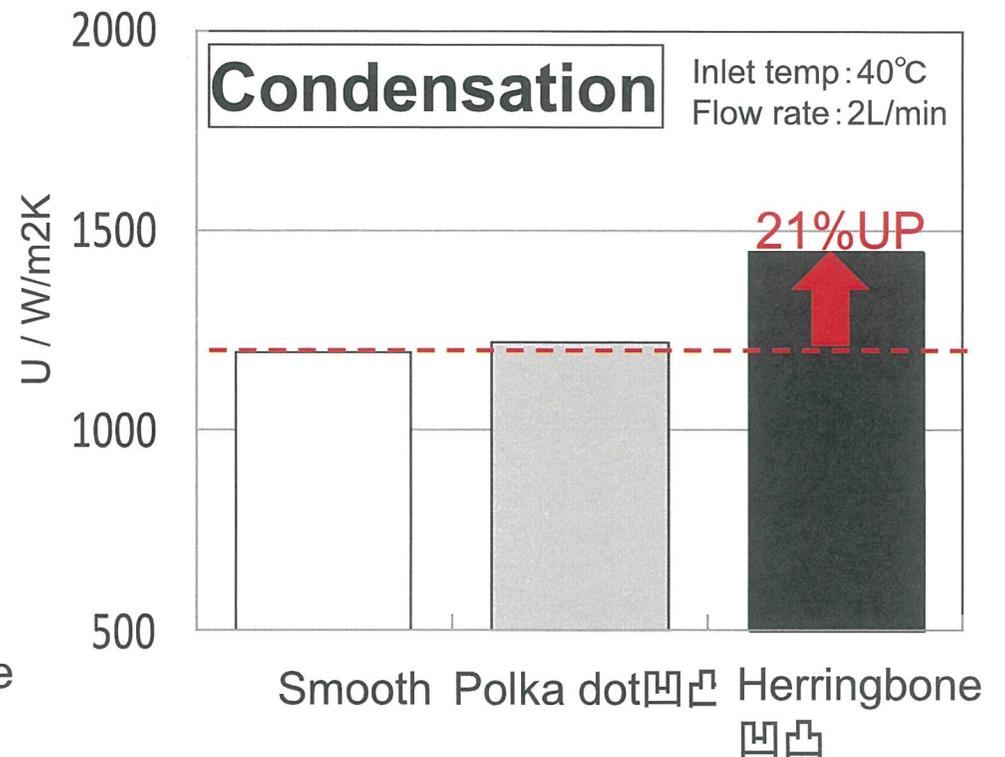
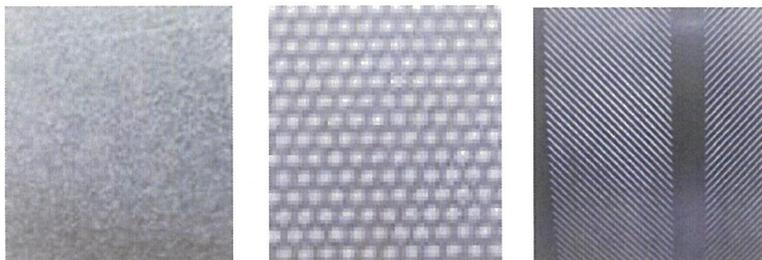
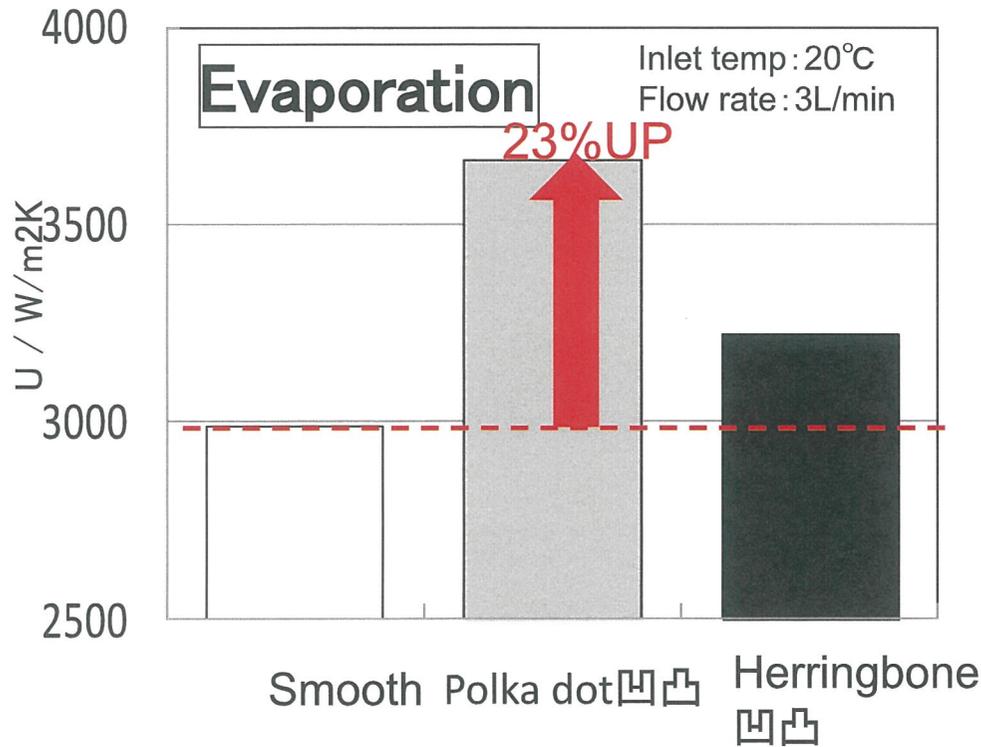


[Manufacturing Key point]

- ✓ **Surface profile control**
- ✓ **Transfer-capability**

Performance Test

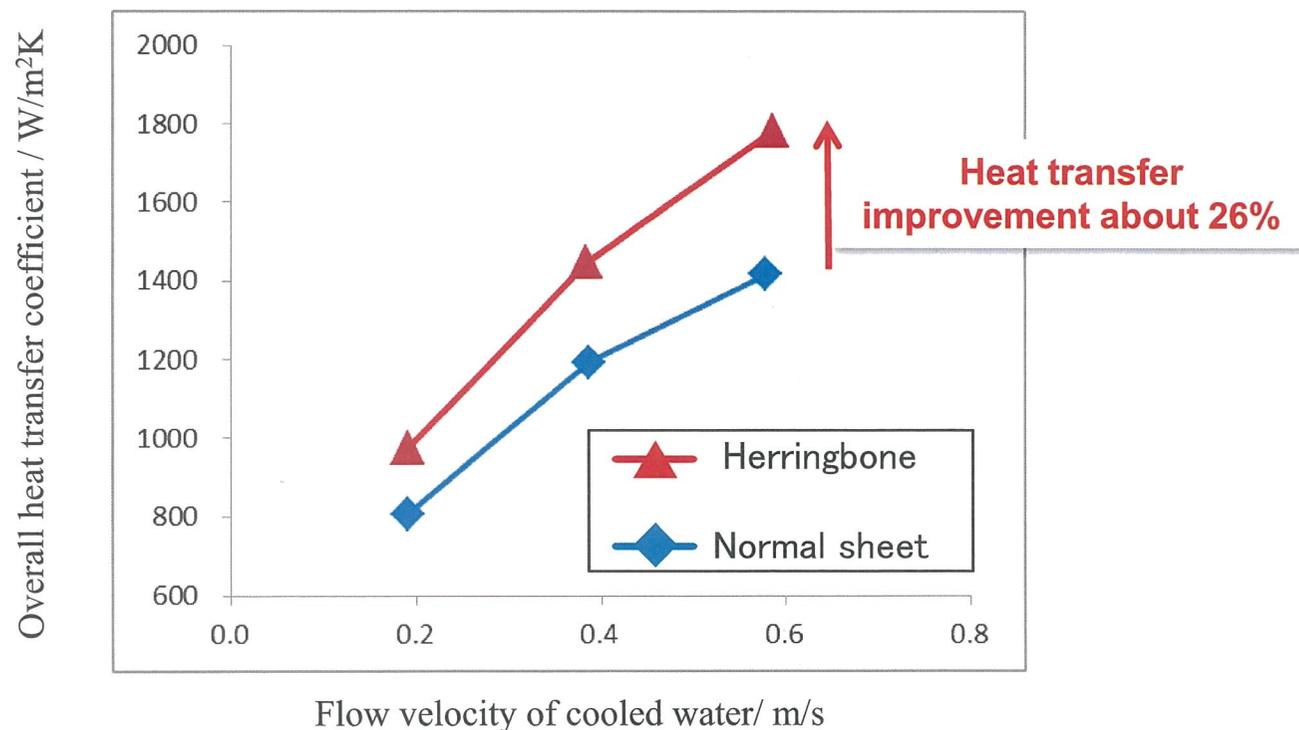
- 20% Up of Heat transfer coefficient on some condision



Production of high heat transfer titanium sheet with higher strength

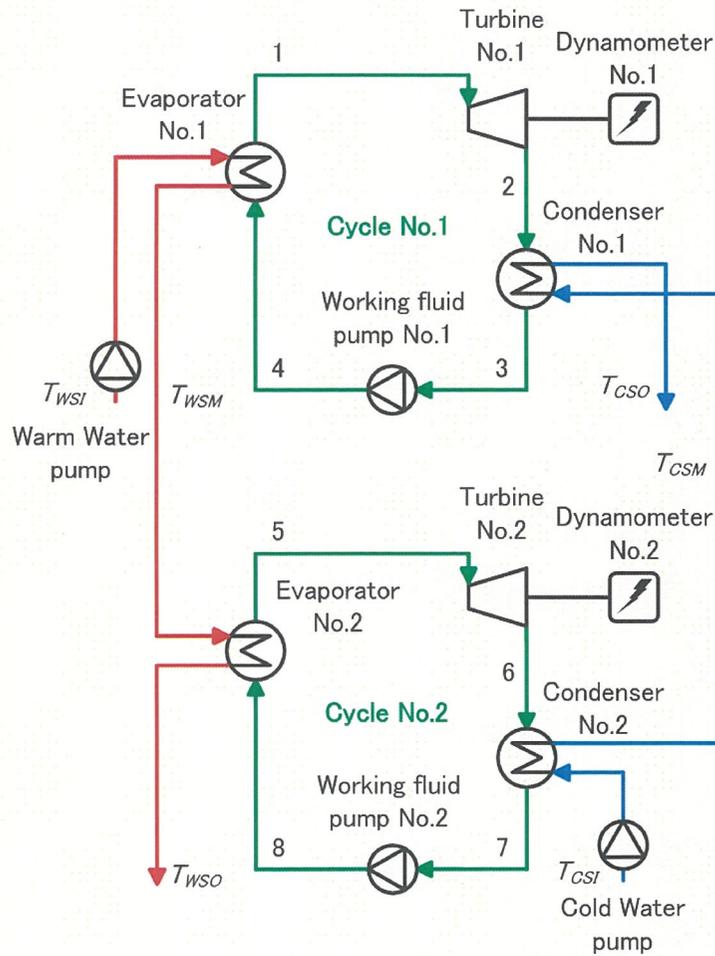
Product

ASTM Gr.2
thickness: 0.5mm
width: ~1000mm × Coil

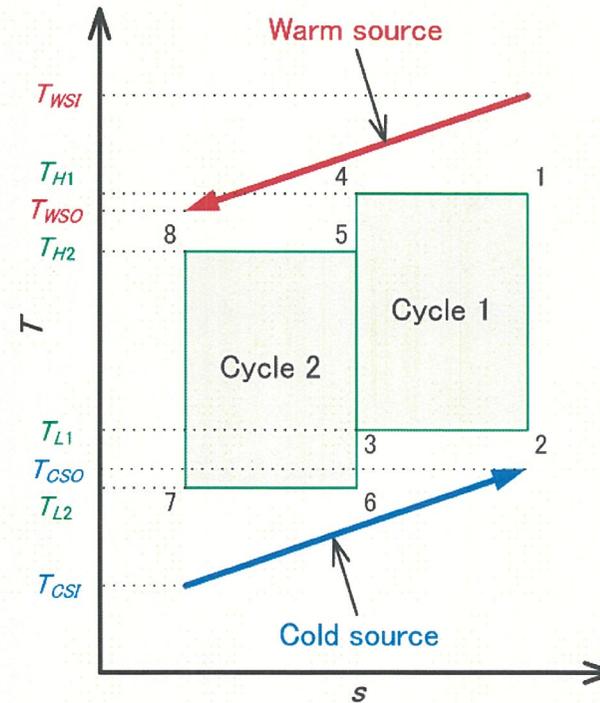


Kobe Steel's Proprietary Information

Double Stage-Rankine Cycle



Double Stage-Rankine cycle flow



(c) Pure ammonia
(Double-stage)

$T-s$ diagram

Okinawa's OTEC Demonstration Project using Advanced Technologies



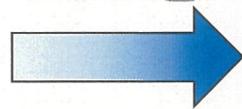
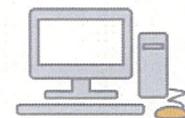
Industry Policy Division Department of Commerce, Industry and Labor
Okinawa Prefectural Government

Performance Prediction from Demonstration Data

Main Differences between Kumejima Demonstration and Commercial Scale Plant

Item	Kumejima Demo.	Commercial	Remarks
DSW Intake Depth	612m (Temp 8~9°C)	800~1000m (Temp. 4~6°C)	Affects Power Generation Efficiency and Self-Power Consumption
SSW Intake Diameter	280mm	1MW class ~1m diam. 10MW class ~3~4m diam.	Thinner pipes at same flow rate are disadvantageous in view of pressure drop
Device Performance	Special design due to small scale/ Off-design operation on seawater side	For 1MW and 10MW class, more commercial equipment is available for design point.	Difference in unit performance of equipment affects power generation output and self-power consumption

Various Demo. Facility Operational Data



Performance Analysis Program

Commercial Scale Performance Prediction



1MW and 10MW Heat Exchanger



Current Demonstration Test Heat Exchangers

Plate Size :

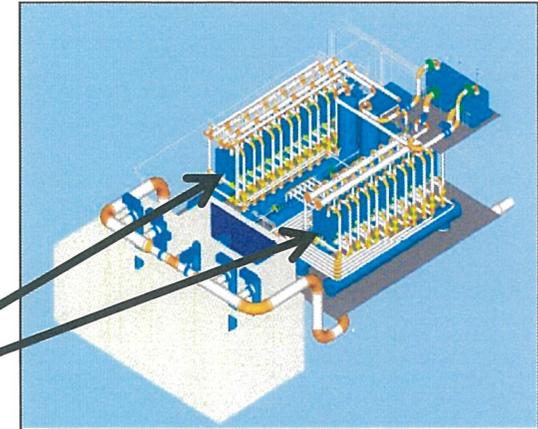
W 0.7m x H 2.4m x
90 sheets / group



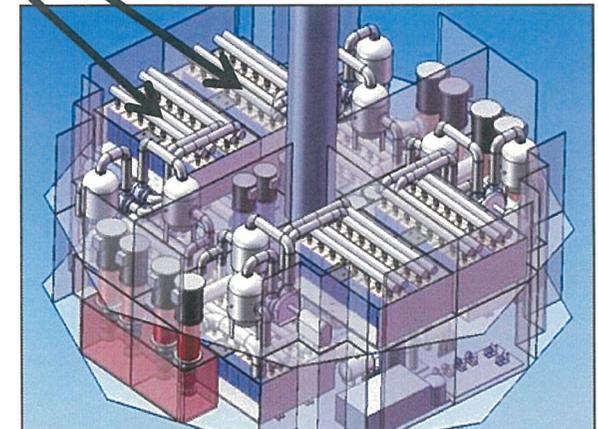
Commercial Heat Exchanger

Plate Size :

W 0.7m x H 2.4m x
240 sheets / group



1MW Class Power Generation Equipment

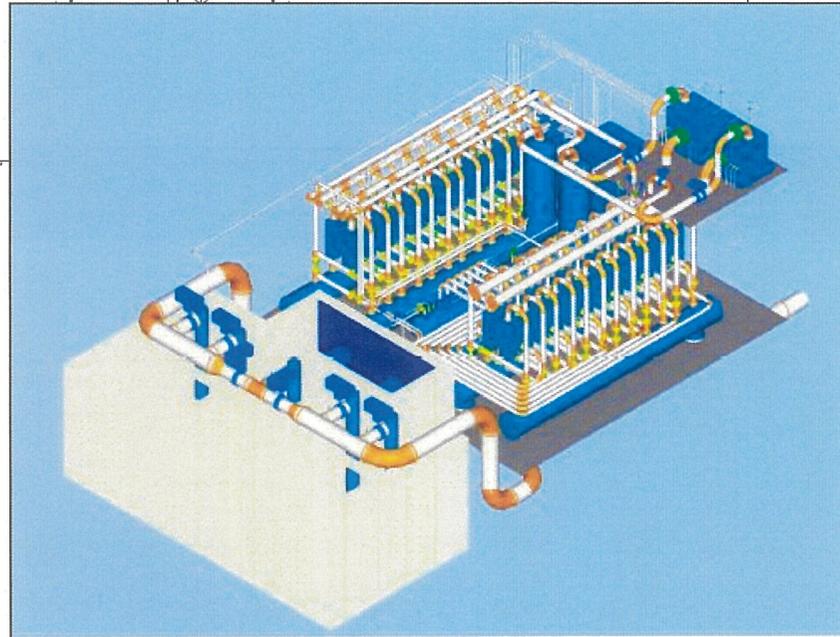
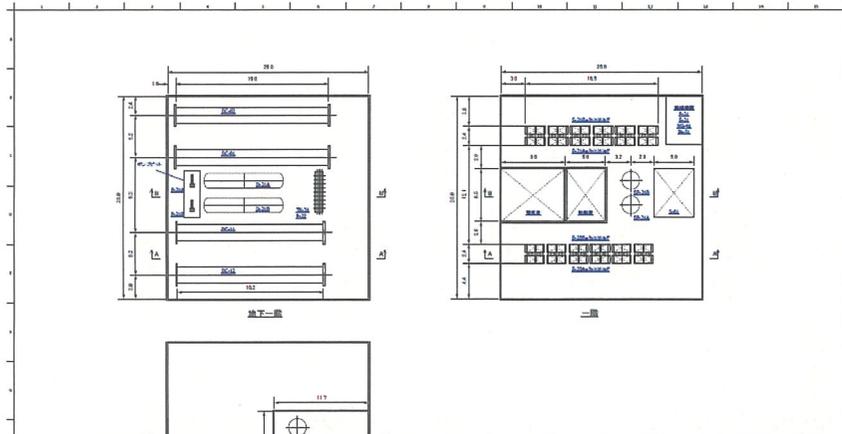


1MW Class Power Generation Equipment

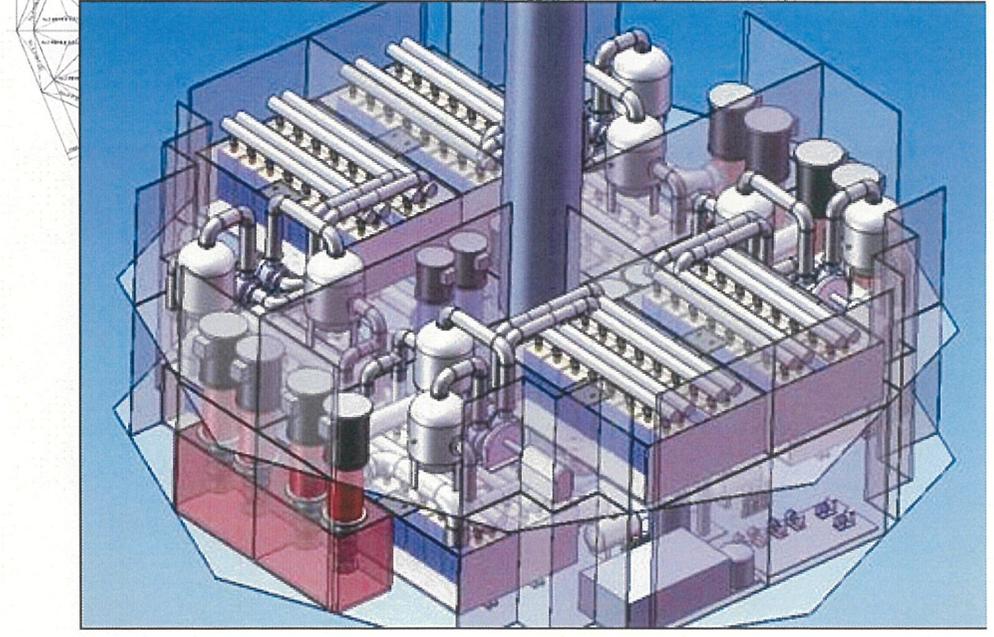
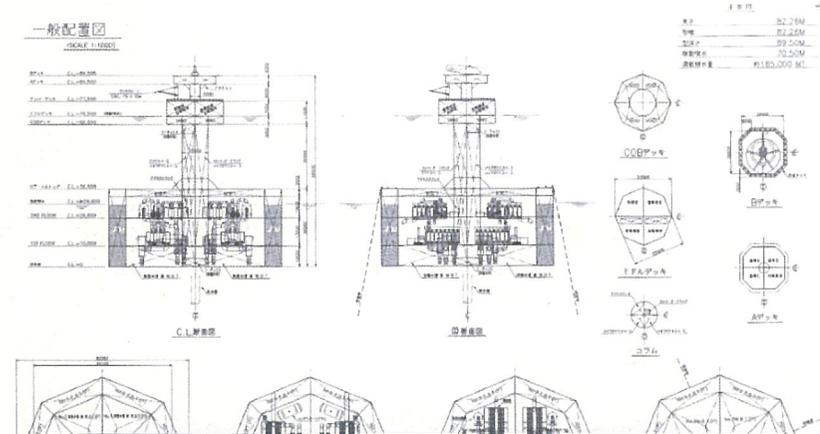
Multiple HX of the same size
can be installed

As the plate size does not change, the same performance estimation formula can be used.

OTEC Detail Design



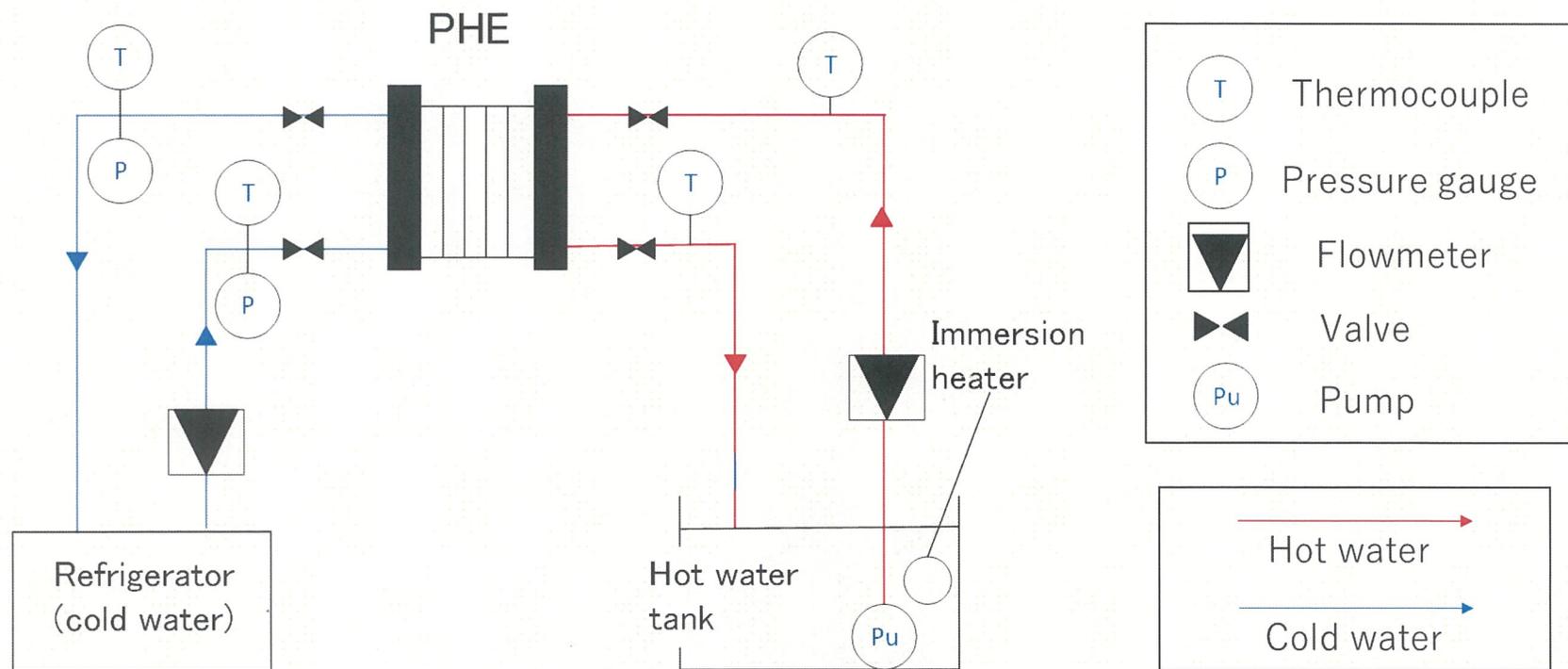
1MW On Land Type



10MW Floating Type

Heat Exchanger Research by Prof. Arima

Experimental apparatus



Test section



Number of plates		N	[-]	5
Cross-sectional area of flow path		A_c	[m ²]	3.46×10^{-2}
Total heat transfer area		A_s	[m ²]	5.49×10^{-2}
Hydraulic diameter		D_{eq}	[m]	4.88×10^{-3}
Number of channels	Hot water side	N_{ch}	[-]	2
	Cold water side			2

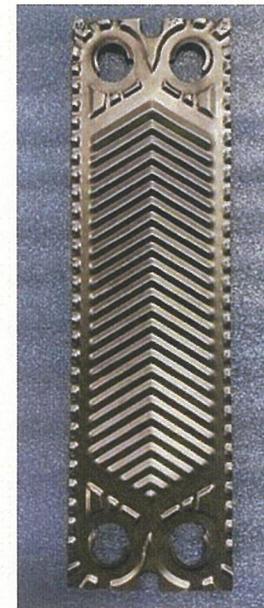
Test plate



A8000 series with
anodized (TP-1)

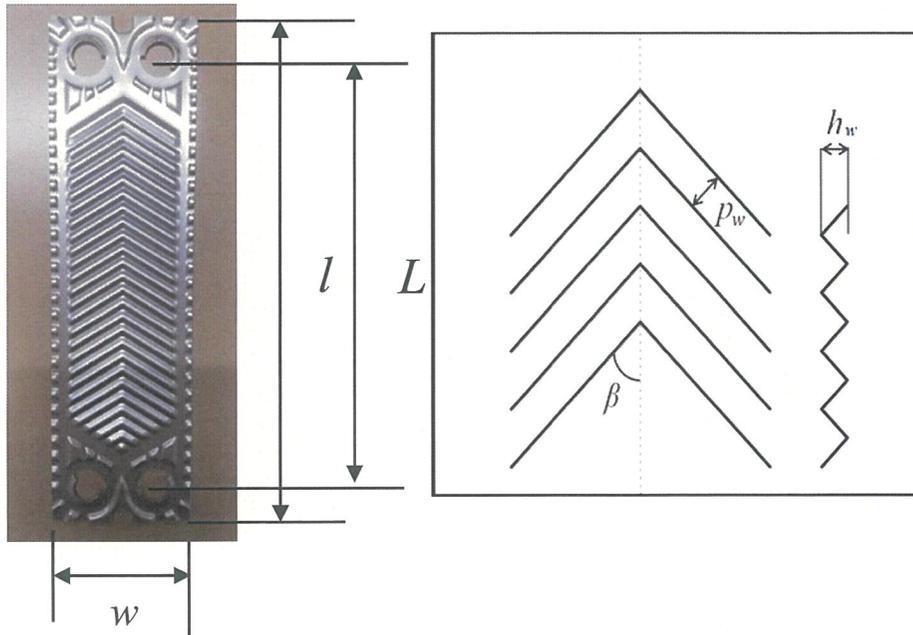


A8000 series with
boehmite (TP-2)



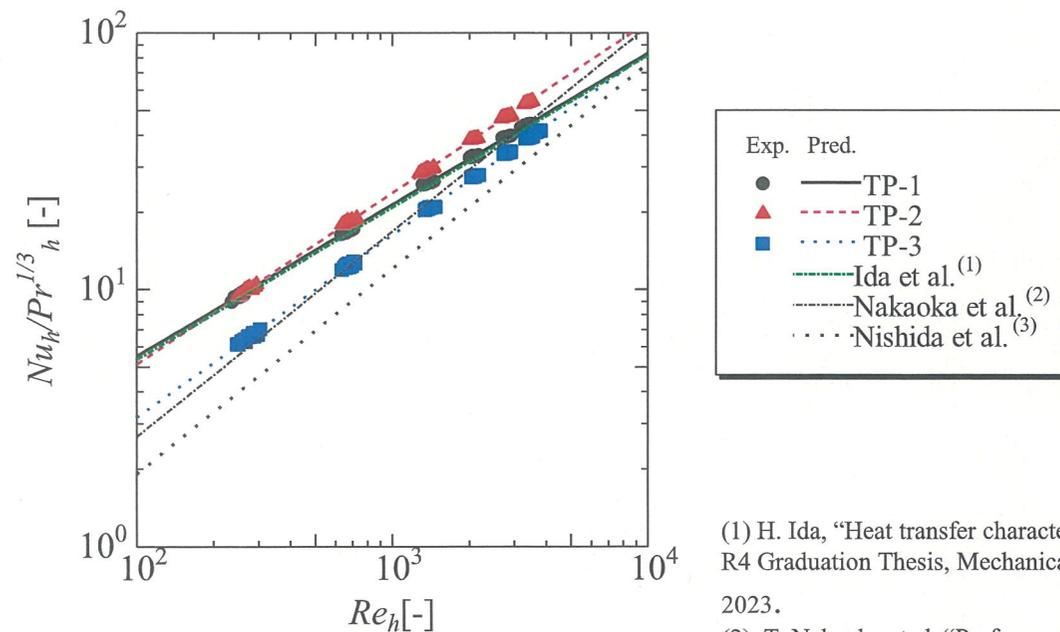
Titanium (TP-3)

Test Plate Specification



		TP-1	TP-2	TP-3
Material		A8000 series		Titanium
Surface Treatment		Anodization	Boehmite	
Plate length	l [mm]	350		
Plate width	w [mm]	100		
Distance between entrance and exit	L [mm]	300		
Thickness	t [mm]	1	0.5	
Wave height	h_w [mm]	2.44		
Wave pitch	p_w [mm]	8.23		
Chevron angle	β [deg]	60		
Heat transfer area	A [m ² / plate]	1.831×10^{-2}		
Thermal conductivity	k [W/m·K]	200		22
Surface roughness	R_a [μ m]	0.211	0.149	0.212

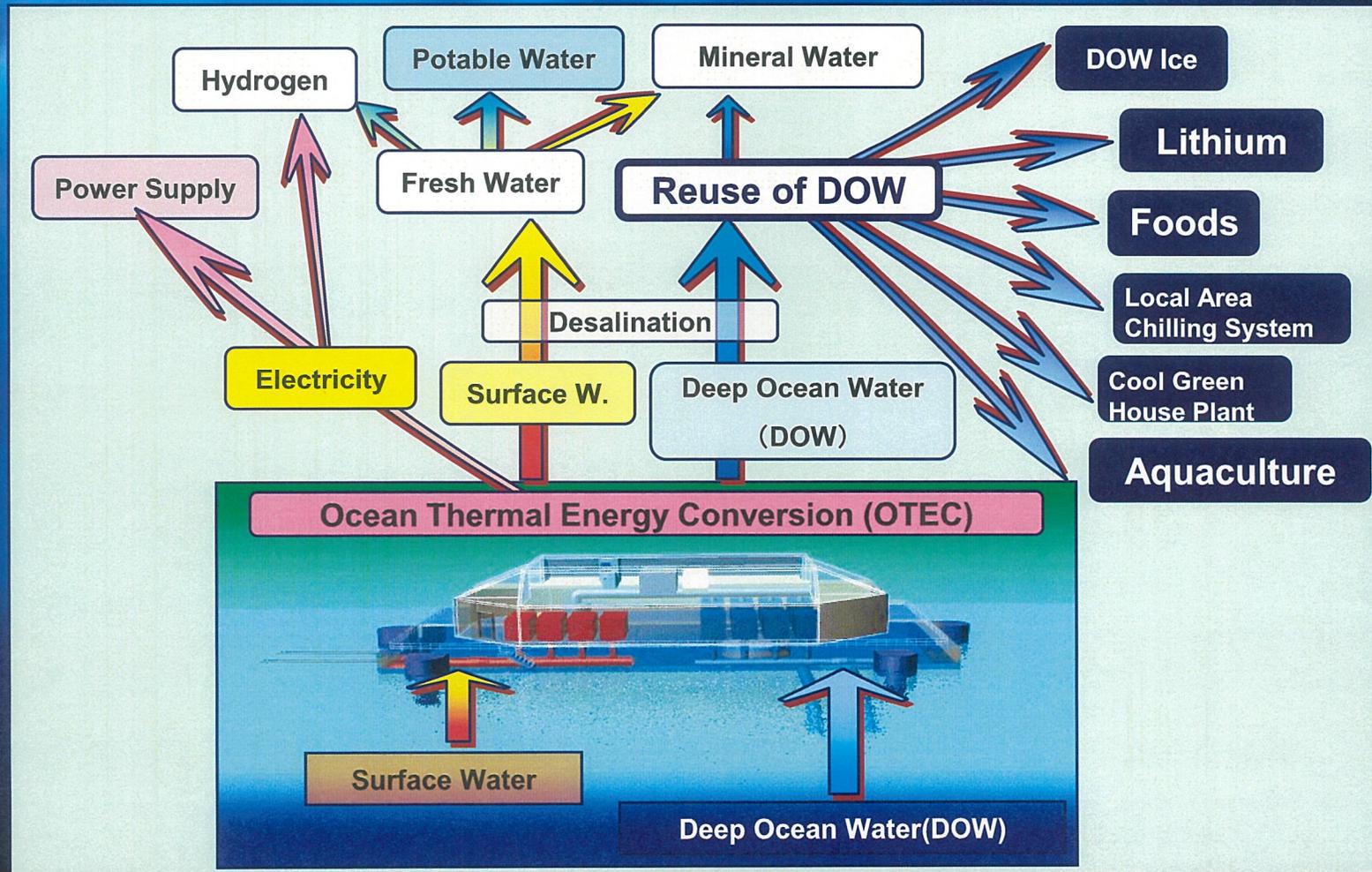
Re_h vs. $Nu_h / Pr_h^{1/3}$



TP-1	$Nu_h = 0.256 Re_h^{0.645} Pr_h^{1/3}$
TP-2	$Nu_h = 0.237 Re_h^{0.667} Pr_h^{1/3}$
TP-3	$Nu_h = 0.121 Re_h^{0.710} Pr_h^{1/3}$
Ida et al. ⁽¹⁾ (A1050 Anodized)	$Nu_h = 0.349 Re_h^{0.592} Pr_h^{1/3}$
Nakaoka et al. ⁽²⁾ (SUS316)	$Nu_h = 0.067 Re_h^{0.8} Pr_h^{1/3}$
Nishida et al. ⁽³⁾ (SUS316)	$Nu_h = 0.048 Re_h^{0.8} Pr_h^{1/3}$

- (1) H. Ida, "Heat transfer characteristics of seawater cooling system with FCU and plate heat exchanger", R4 Graduation Thesis, Mechanical Energy Engineering Course, Faculty of Science and Engineering, Saga University, 2023.
- (2) T. Nakaoka et al, "Performance evaluation of plate condensers", OTEC, Vol. 8 (2000), pp. 1-14.
- (3) T. Nishida et al, "Experimental study of plate condensers for heat pumps", Transactions of the Air-Conditioning and Sanitation Engineering Society of Japan, Vol. 33, No. 138, (2008), pp. 19-28.

By Products of Hybrid OTEC Plant

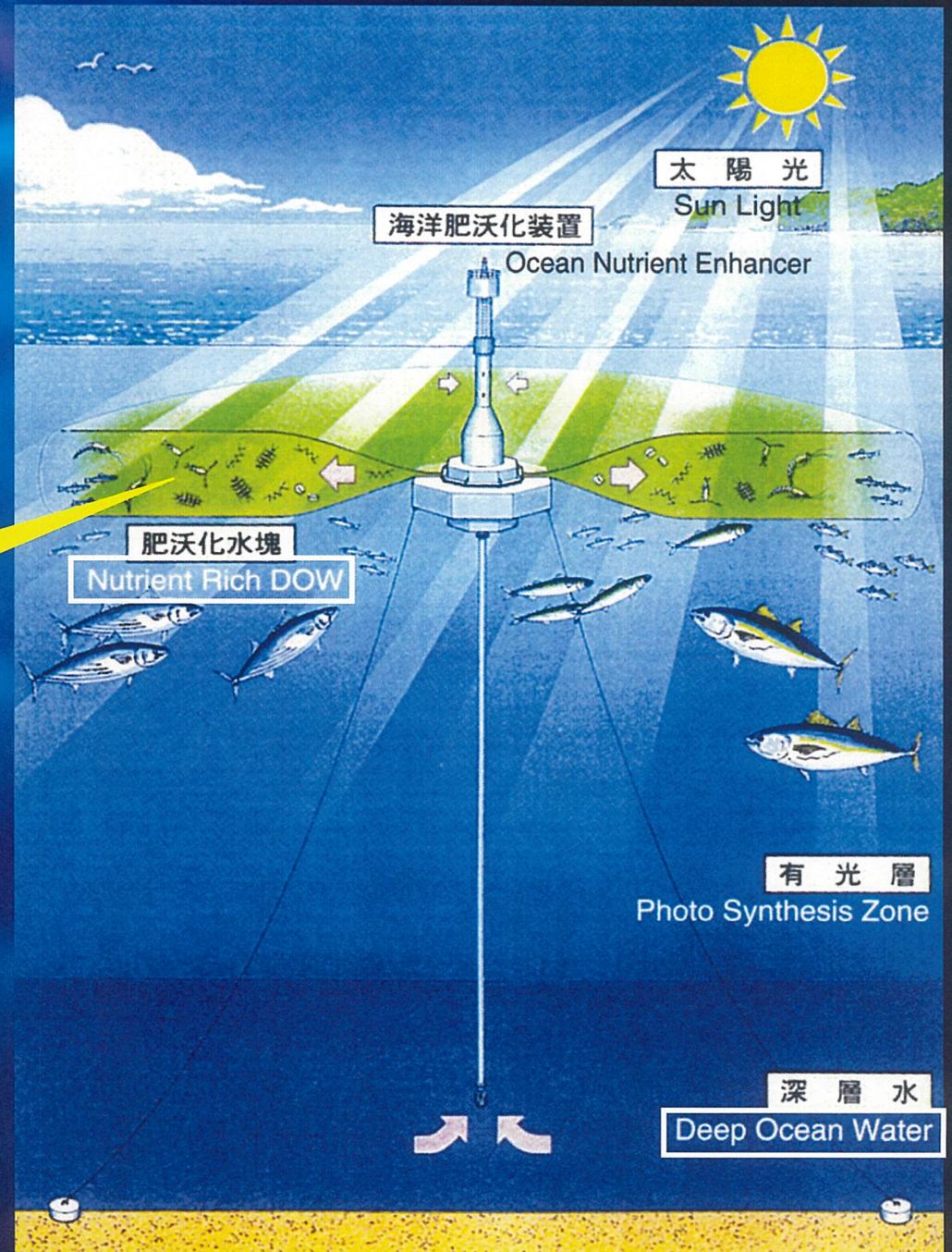


Aquaculture Using DOW

‘TAKUMI’ Project 拓海

Recycling Mineral Rich
Deep Ocean Water

(by Prof. Ouchi,
Tokyo University)



Marine Forum 21 Project



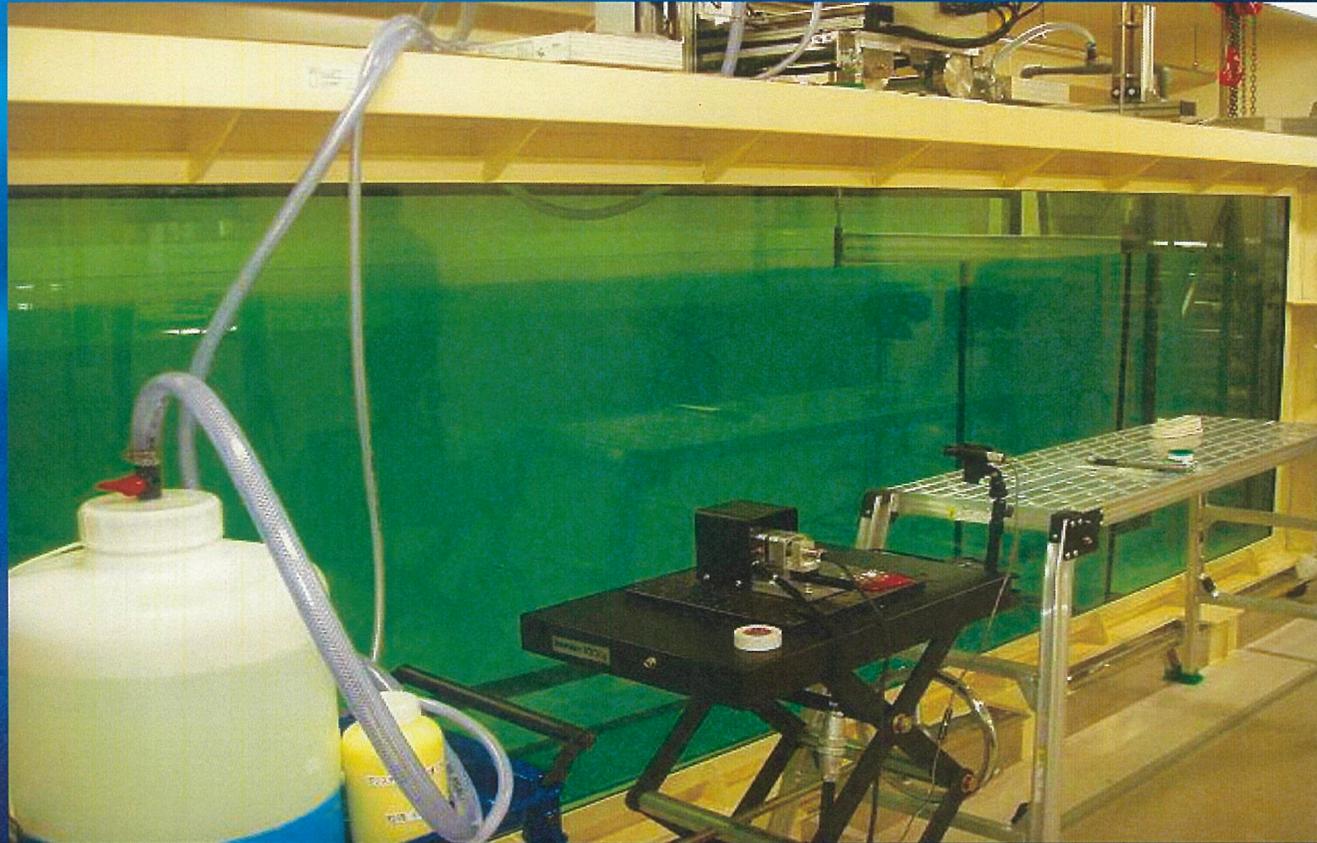
Deep Sea Water 100,000ton(m³)/day

TAKUMI on Operation at Sagami Bay

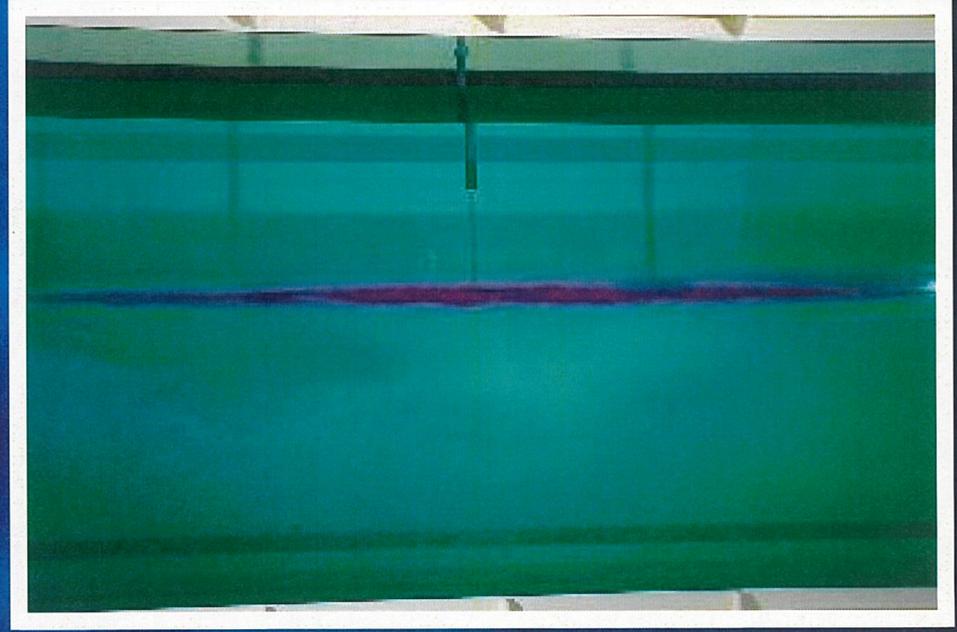
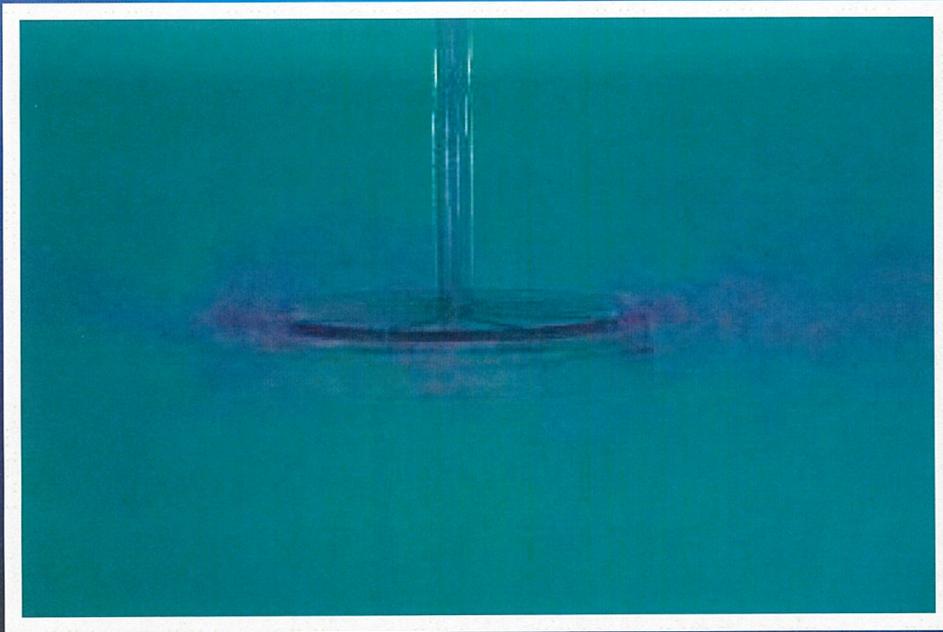


(by Prof. Ouchi, The University of Tokyo)

Ocean Water Simulation System



Simulator for Discharge Seawater



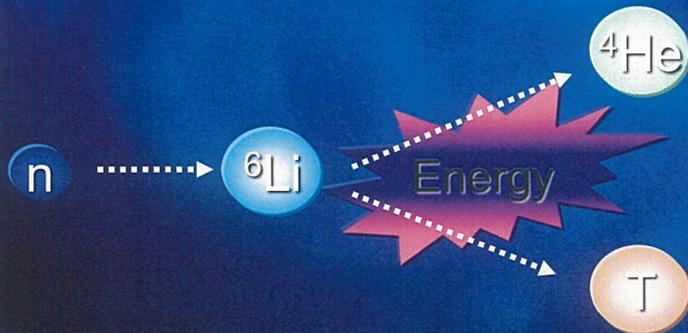
Application Fields of Lithium



Light alloy mixed with Al for aircraft



Electric vehicle without emission

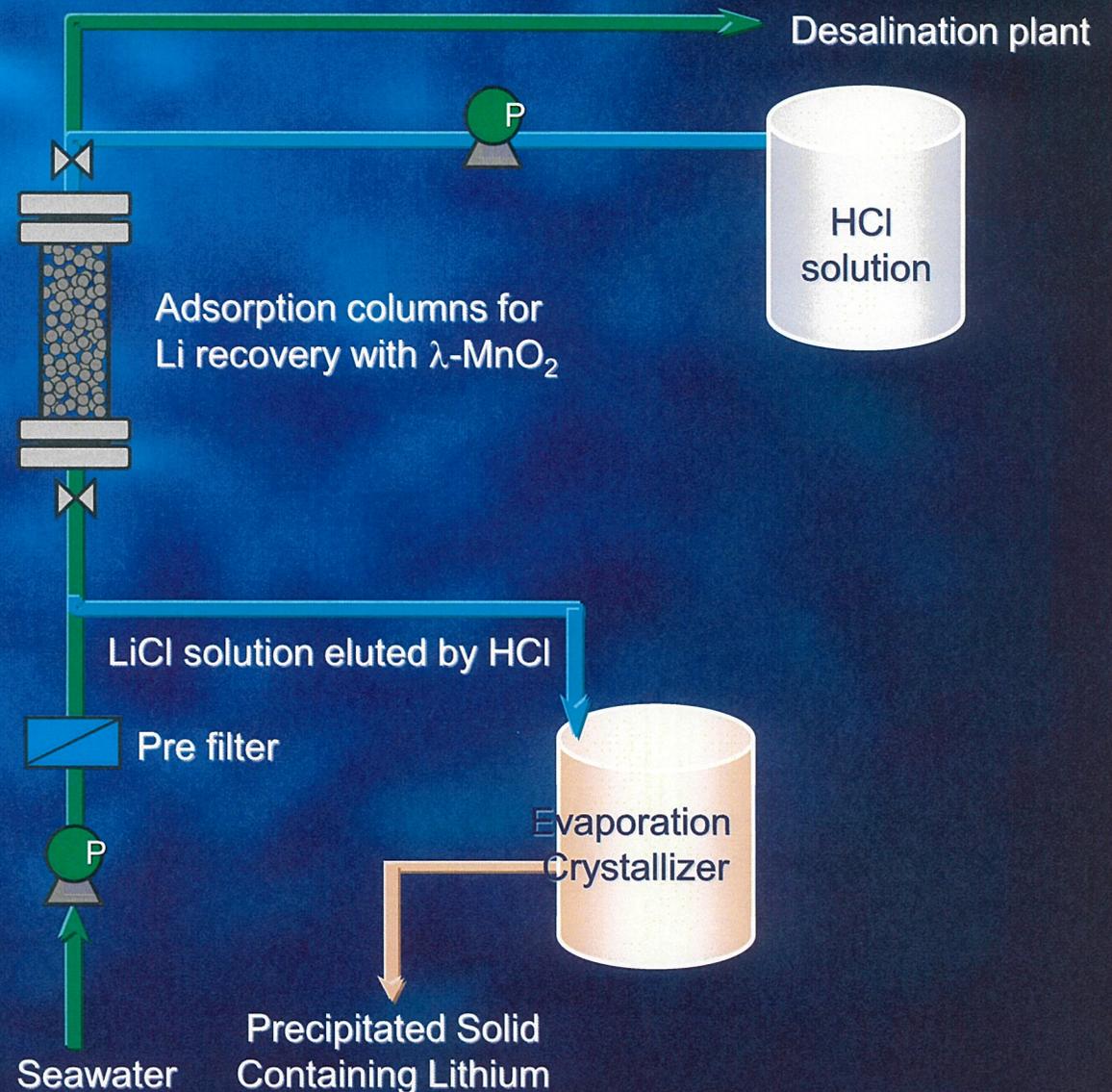


Next energy fuel for nuclear fusion



Rechargeable battery of mobile IT devices

Benchmark Plant of Lithium Recovery from Seawater in IOES



Performance of Equipme

Adsorbent weight: 60 kg

Adsorbent volume: 0.6 m³

Eluting aq. soln. : 0.8 M HCl

Flow rate of seawater supply : 200 L/h

Benchmark Plant of Lithium Recovery from Seawater in IOES

Performance of Equipment

Adsorbent weight: 60kg x 2 columns

Adsorbent volume: 0.6m³ x 2 columns

Eluting aq. soln. : 1-0.2M HCl

Flow rate of seawater supply : 200L/h



Evaporated Salt Obtained from 150 Days Operation



Dried
precipitate
791g

The Components of the Precipitate Salt Obtained from 150 Days Operation

Element	Content [wt%]	Concentration ratio [%]	Content in seawater [wt%]
LiCl	33.3	11,000	0.003
NaCl	20.4	0.26	78.1
KCl	3.3	0.94	3.5
MgCl ₂	8.2	0.57	14.3
CaCl ₂	13.4	4.11	3.26
MnCl ₂	19.4	—	n.q.
SrCl ₂	2.0	50.0	0.04

Thank you very much for your visit.

Prof. Yasuyuki Ikegami

Professor and Director

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